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DEVELOP A BUSINESS PLAN

FINAL REPORT

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Program areas such as research projects, industrial extension, production, and seminars ahve been found to be capable of being self-supporting. The operation of the demonstration facility will continue to depend upon federal funding however.

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EXECUTIVE SUMMARY

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INTRODUCTION

In August 1987 Clemson University signed a contract with the Defense Logistics Agency (DLA) (US Department of Defense) to begin an effort which has become known as Clemson Apparel Research (CAR). Briefly stated, the mission of CAR is to improve the viability of the US apparel manufacturing base. The techniques of technology demonstration, research, technology transfer, and education have been employed in this pursuit. Clemson has always viewed CAR as a natural outgrowth of its mission as one of the original US land grant institutions.

The initial funding for CAR was a three-way effort. Although CAR has been termed a 'DLA Center', the majority of the funding was provided by non-Department of Defense sources. In the funding for the initial three years of operation, approximately $1.3M of federal funds were augmented with $1.9M of University, State of South Carolina, and industrial monies. The non-federal funds were divided into a combination of contributions of indirect costs from Clemson, lease equivalent value of new machinery from the equipment vendors, and real dollars from Clemson and the State of South Carolina. The latter dollars were derived from a short-lived State program, termed 'Cutting Edge' funds, to boost externally funded research at the major State educational institutions and from a continuing State program which returns to the educational institutions twenty-five cents of every dollar spent on externally funded research. Although all of these money sources operated on different calendars, the combination was manageable due to the length of the contract period.

In addition to the core activities funded from the above sources, funds were provided on a delivery order basis for specific research projects. These projects were virtually totally funded by DLA monies. Projects would often require items of equipment or commercial software which could not be purchased from federal funds, due to contract restrictions; these items would then be provided by either Clemson or equipment vendors. Some projects required the assistance of industry; although the commercial value of this assistance is considered as a contribution to the project, it was frequently difficult to quantify and thus never appeared in the formal project budgets.

From the beginning there has been a constant attempt to diversify the funding sources for CAR. Dependence on a single funding source is viewed as too unreliable, given the vagarities of the federal budgeting process as well as the time required from idea inception to project initiation. The first diversification was the gaining of a contract from the US Army Natick RD&E Laboratories for researching the fabrication of a chemical protective suit using stitchless technologies.

Although the stitchless project has been very successful in developing new concepts and applications, it also demonstrates the problems of obtaining other funding. The time from project solicitation to funding was nearly a year but, more importantly, although the project utilizes much of the core facility at CAR, no funds were available for paying for this assistance. Additional personnel skilled in a particular area had to be hired for the technical effort. In essence, the staff became larger, the research more visible, but the long term funding no more stable.

A second area of attempted fund source diversification was identified as a new directive within the National Science Foundation. Traditionally NSF has been the major funding source for fundamental research in the Sciences. Recently NSF has begun providing funds for collaborative University/Industry efforts which deal with broad-based technologies. Funds had to be provided by industrial partners for undirected research at the educational institution. Although industrial input to the research direction was welcomed, actually required, the research could not be in the form of projects for specific companies. Typically, if the University could find ten industrial partners willing to provide on the order of thirty to fifty thousand dollars each per year to a Center, then NSF would provide an additional eleventh share. (The details of each effort vary from Center to Center.)

In 1990 NSF announced a different program; funds would be provided in thirds by NSF, the state where the Center would be located, and industry. The level of NSF funding was also greatly increased to a maximum of $250,000 per year.

CAR attempted to put together such an effort. Although competition was expected to be fierce, it was also thought that CAR would have a unique effort as it was focussed on a generally neglected industry, apparel. Guarantee of the required funds from the State of South Carolina was received. Unfortunately, the solicitation of industrial members was taking place at the worst of the recent recession for the apparel industry and an insufficient number of industrial members were committed by the proposal due date.

One by-product of the attempted preparation of the NSF proposal was a research project funded by an apparel company. The company set up a fund to pay for developmental projects which were specifically beneficial to the company. The level of funding was identical to that proposed for company participation in the NSF Center.

It should be noted that the NSF project structure also required that funds be focussed on research. Although demonstration and industrial extension efforts were not prohibited, they were to be in addition to the core effort. Therefore, this avenue also did not provide for funding of the demonstration facility at CAR although it would have provided funding for an expansion of research projects.

More recently a second major funding source has been procured for the operations of Clemson Apparel Research. In 1992 operation of the Southeastern Manufacturing Technology Center (SMTC), a Department of Commerce program, was transferred from the University of South Carolina to EDI, a private arm of the State Development Board in South Carolina. During the transfer there was also a major change of focus in the programs. Because of its proven record in assisting apparel manufacturers, CAR was asked to become a major participant in the SMTC effort. At this point there has been a major ramp up in two program areas, industrial extension and production, because of the SMTC involvement.

It should also be noted that provision for continued operation of the DLA Apparel Centers was a requirement in the initial program solicitation. Each bidder was required to state how his Center would continue to operate after the initial contract period. At the time of proposal preparation, Clemson University stated that it considered the apparel laboratory as similar to other laboratories within the School of Textiles, which are fully University funded.

Since Clemson is given its budget on a year to year basis, no further guarantee of funding was possible although it appeared that State funding for research and higher education would finally increase after declining for a number of years.

In reality exactly the opposite has happened. The deepening recession and growth of other demands for State funds have led to a progressive decrease in funding for higher education. South Carolina higher educational institutions receive their State funding on the basis of 'the formula.' The formula is developed by the State Commission on Higher Education to reflect the actual cost of educating a college/university student at a comparable southeastern university. The percentage of formula funding has progressively declined from a high of 95.8% in FY86 to a low of 66% in FY 92-93.

This percentage for FY 92-93 represents an after the fact calculation of funds provided to Clemson University. When the budget was approved for FY 92-93, the State fiscal situation was so uncertain and the needs of higher education so great, that the formula was thrown out; the schools were simply provided with an amount of funding. The budget situation at this point for FY 93-94 looks even bleaker; projections show a decrease of $7 million in State funds from FY 92-93 despite a recovering economy.

Internally this decreased appropriation has translated into a consolidation of programs and increased emphasis on user fees. In addition, although the University has been internally allocating funds still according to the formula, there is increasing pressure to drop the link between expenditure of externally generated research dollars and the twenty-five cent return.

Given the State budget situation for the near term, it is not clear how significant monies would be transferred to fully fund CAR's operations if external funds were no longer available. Clearly the scale of the operations would have to be greatly reduced.

The remainder of this report focusses upon the specific CAR activities, including costs of operation and revenue generation capabilities. The specific CAR activities consist of the demonstration facility, research projects, industrial extension, production, and licensing.

CAR ACTIVITIES: DEMONSTRATION FACILITY

The most visible part of Clemson Apparel Research is its 6,000 square foot demonstration facility. The demo area is equipped with approximately $3.4 million of the most modern apparel manufacturing machinery in the world. Although much of the equipment can have many applications, all is oriented towards either shirt manufacturing or research projects.

Approximately 400 visitors per month tour the demo facility. Of this number typically half are associated with either the textile or apparel industries. This group generally tours in small groups, requiring intensive professional resources. The other half ranges from school children to elderly groups. CAR views serving this population as also extremely important to the image of the apparel manufacturing industry (as well as the image of Clemson University as a land grant institution).

These visitors are typically organized into small to medium size groups to give a more personal demonstration atmosphere and for movement through the machinery area. A CAR engineer leads each group. At each operation, the sewing operator will describe her function as well as how the machine operates. The engineer tries to give the group an overall feel for the apparel manufacturing industry as well as for CAR's mission and accomplishments. A tour generally lasts between one and one and one-half hours.

Virtually all of the machinery is placed on consignment by the equipment manufacturers or distributors. The general agreement between CAR and the consignors is that CAR will pay for shipping the machinery to and from Pendleton, SC and will make certain that the equipment is maintained in good working condition. The actual maintenance varies with the scale of the effort required and the policies of the consignor but typically CAR's engineering staff performs the maintenance with original parts and makes all style changeovers.

This situation requires a high level of skill from the engineering staff and constant training. Because of the demo facility's role in showing the latest applicable technology, the facility has much more diversity in even the basic types of machines than a typical apparel manufacturer would have. This additional consideration has led to what has been described as a 'mechanic's nightmare', requiring an even higher level of training and skill from the staff. Also there is a

constant turnover of machinery as improved models are received from equipment manufacturers and the old ones returned for sale.

These demands are also seen on the sewing operators and the sewing floor itself. Each operator must be able to handle proficiently a greater number of machines and operations than a production facility would require. In addition, the research projects and short projects mean that a constant flow of different work comes through the demo facility. In essence, between the demonstrations of equipment and techniques and the projects, the demo facility functions more like a sample making facility than a production facility.

An example of this situation is the recently completed research project for the US Army Natick RD&E Laboratories on the redesign of the women's army dress shirt. In the second portion of the project, the CAR demo facility produced shirts for the fit and wear testing of the redesigned garments. A total of 880 shirts in 4 styles and 56 sizes were manufactured. No more than four identical garments were produced. Although the wide range of styles and sizes provided an excellent test bed for showing the flexibility and changeover times of the automated equipment, it was also a challenge for the operators to produce defect-free garments.

Continuity in manufacturing in the demo facility is provided by limited production of the men's short sleeved Army dress shirt, AG415. Portions of this garment are used to demonstrate the capabilities of CAR's equipment. Initially, CAR did not intend to actually produce any finished garments; however, the costs of sewing labor and materials associated with demonstration demanded that these funds be recouped through sale of finished shirts. Accordingly, CAR signed a series of contracts to deliver the AG415 shirts to the Defense Personnel Support Center.

For the last few years CAR has produced approximately 10,000 shirts per year. The work has been divided into production of small parts using automated equipment as part of demonstrations by the CAR full-time operators during Monday to Thursday followed by assembly and non-automated parts by part-time operators on Fridays. Special tours and major events such as open houses follow the larger scale Friday schedule.

Revenues received from the sale of the green shirts are sufficient to cover the costs of the materials and the part-time sewing operators. Revenues are not adequate to cover the direct and indirect costs of the full-time CAR sewing operators who are demonstrating machinery; due to the way demonstrations are handled, production efficiency tends to be very low. Increased production efficiency can only be gained by losing many of the benefits of demonstration such as having sewing operators talk to visitors about their machine capabilities. Thus, covering the costs of demonstration by increased production can only be achieved by degrading the benefits of operating a demonstration facility.

Total direct costs of operating the demonstration facility are $800,000 annually. This amount includes personnel who act as receptionists, tour guides, training

instructors and schedulers, maintenance and installation engineers, and sewing operators; and materials for demonstrations only and parts. It does not include the value of the equipment since it has generally been consigned to CAR nor does it include facilities costs such as heat, air conditioning, light, etc. since they are included in Clemson's indirect cost rate (currently 44%).

RESEARCH PROJECTS

Research projects are typically conducted by a combination of CAR personnel and more traditional academic personnel such as tenure track faculty and graduate students. The skills brought to the projects by the two groups tend to be distinct.

Faculty and graduate students offer fundamental expertise in a field of science or engineering. Often the faculty have many years experience in developing a well-defined area of research but little knowledge of how their expertise can be applied in apparel manufacturing. Graduate students offer fundamental knowledge and much enthusiasm but only a partially developed capability for handling either the fundamental science or its applications to apparel manufacturing.

On the other hand, CAR's fulltime personnel have years of experience on the floor in apparel manufacturing. Thus they can complement and teach the faculty about the particular requirements of a such implementation of a new technical area. A typical contribution might be in the design of information and its display for an apparel manufacturer. It is important to note that the CAR staff generally are not capable of performing the fundamental development of new technology, particularly in areas which are highly computational or database oriented; the faculty thus complement the CAR staff limitations.

One advantage to using faculty on research projects is that they are paid 100% by Clemson University during the academic year. Therefore, they can be readily shifted back to more traditional research pursuits during periods of lapses in project funding.

The typical cost of a faculty research project is on the order of $150,000 per year. This amount covers the cost of several months of faculty time, a graduate student or research assistant, associated supplies and travel, and indirect costs. A small amount of CAR staff time may also be included for advice during the initial stages of a project and assistance for implementation during later stages.

CAR staff can not be used as flexibly as faculty because they have no second, guaranteed source of funding. Thus the CAR staff have to be shifted from project to project both as they are needed and as funds are available. This later restriction means that there is tremendous pressure to identify and hire people with many skills and much experience in the apparel industry.

A major limitation to research project funding is that it rarely contributes to the fundamental costs associated with the demo center. Although research projects generally require access to the demo center personnel and their expertise and

often access to machinery in the center, the projects tend not to include sufficient funding for covering the associated costs.

In summary, it can be said that research projects tend to cover their direct costs but do not provide any source of funds for the core operation of the demo center.

INDUSTRIAL EXTENSION

Industrial extension can be viewed as the manufacturing counterpart to agricultural extension, an area operated by most states through their agricultural colleges for nearly 100 years. Clemson University has such experience as the land-grant college in South Carolina. The successes of the agricultural extension programs in developing American agricultural production are well known.

Funding for agricultural extension has traditionally been provided by the federal government and by the counties within the state service areas. Initially the funding at Clemson for such efforts was substantial; Clemson operates a number of agricultural experiment stations as well as stations agents in every county. In recent years the ag extension area has been the part of the Clemson program most severely impacted by funding decreases. In the last two years, reductions in force and program pruning have become routine. This situation is echoed in most other state programs. It should be noted that the ratio of extension personnel to active farmers is considerably higher than exists in other areas of federal support for production activities.

Manufacturing extension is a recently developing area for most states. CAR was given the opportunity to expand into this area through an association with the Southeast Manufacturing Technology Center in South Carolina. This program is funded through the Department of Commerce, NIST. The CAR subcontract with SMTC provides $250,000 per year for extension efforts. A small portion of the funding can also be used for development of products to be applied to the apparel industry.

The SMTC program has permitted CAR to add three full-time persons who work directly with the industry on technology applications. Charges (at a fixed rate per day) are made to apparel companies for consulting services rendered. The industrial fees are used to partially offset the cost of personnel and supplies and equipment. At full loading, the manufacturing extension effort is expected to be self-supporting although that point has not yet been reached.

A major drawback to the SMTC operation is the DOC requirement for fund matching. In the current year, for every one dollar of federal funds expended, two dollars and thirty-three cents in non-federal matching funds are required. The match can be a combination of cash and in-kind but at least 40 percent of the match must be cash. In addition, the SMTC contract does not permit CAR to capture indirect costs although these costs may be used as part of the cash contribution.

Because of the need to generate large amounts of cash match, CAR decided in March 1993 to increase its production activity.

PRODUCTION

Arrangements were made with a local small business, an apparel manufacturer, to manufacture dress shirts on a subcontract basis. This manufacturer has a number of contracts with US retailers to produce a varying range of men's and women's shirts. Although there is considerable variation in the styling, all the shirts fall into the category of dress shirts and thus lend themselves to the type of equipment located in the CAR demo facility.

A small production team was hired in March 1993 to handle this subcontract production. A production manager, mechanic, cutter/material handler, and fourteen sewing operators were hired as grants employees. This categorization means that the employees are not considered permanent state employees but are employed only as long as the technical and financial needs exist. CAR was given special permission to pay a base hourly salary with a production incentive.

Training of the production operators was performed by the existing CAR operators and trainers. It was quickly found that a dependable source of work was critical to the smooth ramp up to production. At this point the operators are approximately at 80% of the training curve for single operations in assembly and multiple operations in parts. During the training period, CAPS was found to be an effective incentive tool.

The move to production has highlighted a number of problems associated with the use of automated machinery in small, short run manufacturing. Many tooling changes have been required for the different style changes in parts manufacturing. Often tooling has been received after the production orders had already been delivered. Because of the tooling problems, some production operations have been performed at the local manufacturer rather than at CAR.

One area of particular concern has been cutting. Because of the short spreading length available at CAR due to the short room length, it has been difficult to achieve needed production material utilization efficiencies. Thus, the automatic machines have been run with hand cut parts of variable quality, further degrading operator efficiencies as they struggle to maintain high quality. This limitation is expected to be remedied as soon as the planned expansion of the demo floor is handled by the University.

At this point, the production operation generates sufficient revenue to cover its direct costs including fringe benefits but does not totally cover indirect labor expenses. At full operation production is projected to generate a profit of $150,000 per year. This number is predicated upon continuing to have a steady flow of work and no more expensive tooling or re-training expenses.

Licensing

Although the original intent of the research projects was not to generate saleable products, several of the projects have done so.

The first product which CAR could sell was a spreadsheet for assisting manufacturers trying to set rates for modular installations, termed CAPS (Clemson Apparel Productivity Share). CAPS was developed from the research conducted during the Flexible Manufacturing project. In this project it was identified that apparel manufacturers could achieve significant manufacturing improvements by the installation of manufacturing modules in some operations. It was also clear that manufacturers had not developed standard procedures for determining which operations should be in modules or how to pay operators. The later issue is an extremely important one since most apparel manufacturers would be switching from a bundle-based, individual incentive system which paid operators on the basis of pieces sewn to a modular team approach.

CAR's researchers developed software, based on a spreadsheet approach, which could help manufacturers take into consideration a gain-sharing system for paying operators and indirect personnel. The intent of the spreadsheet was to give manufacturers a simplified summary of their pay options with built-in calculations.

CAPS was introduced at the Bobbin Show in 1990 and was immediately proclaimed a hit of the show by the press. A major upgrade, including a graphical display, was developed during the spring and summer of 1992. A user's manual was also written for the new version.

To date, 11 copies of the software have been sold at $250 to $695 per copy. (Later upgrades led to a higher price for the software.) It is anticipated that further upgrades will be necessary to incorporate other new ideas for profit sharing.

The first product that CAR has licensed is VAST (Voice Actuated Sewing Technology). VAST consists of a small box containing a special voice chip (and other electronics), a microphone, and links to a personal computer and an electronically controlled sewing machine motor. When the box is connected to the PC, then an operator can teach the box to recognize her voice saying a list of controls. The PC is then disconnected and the box retains the voice commands. The operator can then link the box to the controls of an electronic sewing machine motor. The box then relays her voice commands to the sewing machine.

In effect, VAST permits a sewing operator to substitute her voice for direct mechanical or electrical links to the motor. Any motor function can be programmed to be controlled by voice.

Three markets already identified are handicapped operators, large products, and modular manufacturing. There are clearly advantages for the handicapped operator, particularly with limited lower body function, to control the machine with something other than their hands since hands are needed for guiding work.

The voice control also permits the operator to move away from the machine while sewing such items as quilts or long seams. In modular manufacturing VAST permits the use of standup operations without the ergonomical disadvantages of the current machine controls.

Refinements of these areas as well as other potential markets are being considered by the CAR staff.

VAST was developed during the summer of 1991 for display by the Efka Company during the 1991 Bobbin Show. The industry interest in the device (and further technical developments by CAR) led to a license of the technology to Efka in 1992.

The license was drawn to include an upfront payment to CAR as well as payments per unit sold. A minimum number of units must be sold each year for Efka to maintain its exclusive license for controlling electronic sewing machine motors.

Recently DBH Limited has also licensed the voice technology. DBH intends to use the technology for permitting an operator to control one or more air cylinders. the air cylinders are presently incorporated in DBH's products for controlling such functions as clamping and releasing fabrics. The voice technology is a simplified version of the original VAST boxes since there is only a small number of control words needed.

A major impediment to the industry acceptance of the technology is the cost of the voice boxes. The current design, incorporating voice chips approximately ten years old, requires a delivery price by Clemson to a potential vendor of $1600. When the vendor's markup is added, the technology becomes non-competitive with more conventional controls. Recently, the chip supplier indicated that he could refine the chip design to reduce the price. When further streamlining from CAR's researchers is included, the VAST manufacturing cost is expected to be on the order of $325. A simplier box such as the one licensed to DBH would cost on the order of $150. These prices will permit the selling price to the apparel manufacturer to be on the order of the price of a current footswitch.

A third product which is nearly ready for sale and/or licensing is the CCC shade sorting software. Here the potential markets are individual apparel and textile users as well as instrument manufacturers of color measuring equipment. Currently it is envisioned that there will be several different products with varying prices and agreements. One product could be the core CCC shade sorting code which the user could then incorporate into his own software as he wished. This product would be sold at low cost to individual users as well as licensed to equipment OEMs. Licenses would contain provisions similar to the Efka license on upfront charges and minimum annual sales.

A second variation is the addition of major inventory handling techniques to the core CCC code. This addition gives greatly enhanced usefulness to a typical apparel manufacturer, permitting the typical user to really use color information. It is envisioned that this version will be licensed to the individual users. A

separate agreement would be needed with any OEM who wanted the inventory capability.

It is worth noting the fundamental issues related to getting these products into the hands of US apparel and textile manufacturers. First, the research and development were paid for, at least partially, from government funds. Early in the research program development, the government agreed to the universities handling sales, marketing and licensing with COTR oversight. All profits from the sales were to be returned to the apparel centers for the purpose of funding further apparel research. The government retained the right to license the items for its own use. (In practice, 'its own use' translates into copies for the DPSC factory in Philadelphia. Government contractors are not included in the definition government use.)

Second, there is no fixed format to how the licensing or sales agreements are structured. The agreements depend upon how CAR perceives the market and how best to get the technology into the market, in consultation with its industry partners and the COTR. Thus exclusive licenses are possible if they are deemed in the best interest. Otherwise, non-exclusive licenses are preferred.

Third, there is currently no fixed provision for maintenance of the technology. At present the maintenance is primarily supported by DLA funding of the original research effort but this situation is not expected to continue indefinitely. It is anticipated that CAR will have to support the maintenance and continued improvement of the products from the revenues generated. This area is still being formulated but it appears that a business plan will have to be developed for each product. The CAR staff and researchers will have to develop a plan for anticipated revenues as well as costs of maintenance and upgrades. In this context it should be noted that such items as disk and manual duplication and mailout are minor expenses relative to the cost of the possible technical effort.

Overall, it is projected that a good product might be able to generate total income similar to the amount of funding necessary to develop it originally and pay for its maintenance. A 'winner' such as VAST potentially could generate significantly more revenue than its development costs, thus funding the research and development of other items. At this point however it will be several years before CAR knows how successful these products will be.

Other Potential Funding Sources

Since the beginning, CAR has held a number of continuing education seminars and courses. These courses include a basic overview, Fundamentals of Apparel Manufacturing, and advanced courses in areas such as Modular Manufacturing. Attendance at the courses ranges from generally about fifty to sixty persons at Fundamentals to twenty at the more specialized programs. Total revenues for a year are on the order of $150-200,000.

The revenues associated with the courses typically cover the expenses associated with the courses such as publicity, meals and speakers' expenses. There are no additional profits generated to cover other demo expenses however.

In general the recent experience of the Professional Development group at Clemson and the industry seminar/conference organizers is that attendance is down, possibily due to poor business conditions and consolidations within the manufacturing industries. Finding new 'winners' is becoming a more difficult search each year.

CONCLUSIONS

The non-demonstration activities of CAR have demonstrated a capability to generate sufficient funding to cover their direct and some indirect expenses as well. In particular, research projects funded by federal sources cover their costs. The demonstration activities cannot totally be covered by non-federal sources; in general an increase in the costs covered by non-federal sources has tended to limit the flexibility of the center to respond to industry needs. It should be noted that many of the other activities at CAR are dependent upon the attraction offered by the model factory.

The increased emphasis on production activities in the demo center, required by the match commitment for the SMTC affliation, has led to increased credibility of CAR within the industry. CAR is now viewed as being more 'real world' by many manufacturers since it must now cope with more problems similar to the daily problems of the apparel manufacturer clients.

An important addition to CAR during the last year was a group dedicated to manufacturing extension. This group forms the core of in-plant work to modernize small and medium sized apparel manufacturers as well as forming the beginning of an effective mechanism for transfering the technology and management ideas developed at CAR. Continuation of this effort will depend upon receiving a combination of NIST and industry fees for consulting services.